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PERFORMANCE OF SEVERAL AIRCREW LIFE-PRESERVERS IN CONJUNCTION WITH VARIOUS CLOTHING ENSEMBLES

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DEFENCE AND CIVIL INSTITUTE OF ENVIRONMENTAL MEDICINE

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PERFORMANCE OF SEVERAL AIRCREW LIFE-PRESERVERS IN CONJUNCTION WITH VARIOUS CLOTHING ENSEMBLES

N.A. Martin

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Defence and Civil Institute of Environmental Medicine
1133 Sheppard Avenue West, P.O. Box 2000
Downsview, Ontario M3M 3B9

DEPARTMENT OF NATIONAL DEFENCE - CANADA

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ABSTRACT

Three currently-available life-preservers were tested to evaluate their performances compared to the current jet aircrew model, when worn by five representative subjects wearing three different Canadian Forces flying clothing ensembles. Parameters tested were: maximum buoyancy provided, subject mouth-level above water, subject flotation angle, and time to self-right the inert subject. Results indicated that all but one of the life-preservers tested met the ASCC Standard of 35 pounds buoyancy, two met the five-second limit for self-righting, although none would right the immersion-suited subject, and none achieved the optimum 45 degrees flotation angle.

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INTRODUCTION

The three types of aircrew life-preserver currently in use in the Canadian Forces (CF) are modified versions of very old designs (1). There is little difference between the jet aircrew model, NATO Stock No. (NSN) 4220-21-871-6316, and the one used during the Second World War. and none of the current equipment meets the minimum specifications of recognized standards (1) such as the British Standards Institution (BS3595) (2), or the Air Standardization Coordinating Committee (ASCC) Air Standard (Air STD) 61/4 (3) which has been ratified by the CF.

In his review of incidents/accidents involving CF aircrew over the past twenty years, Brooks (4) found that the life-preservers in use have generally given good service, but that there is room for improvement and that one model used in Maritime Command, the Buaer, should be replaced.

The 1977 draft Statement of Requirement (5) outlined the shortcomings of the current life-preservers. This draft was superceded in 1984 with a SOR that includes the specifications of ASCC Air Standard 61/4. The following are required:

a. inflation within five seconds;

b. maximum self-righting time of five seconds;

c. optimum flotation angle of 45 ± 10 degrees from vertical;

d. minimum buoyancy of 16 kg (35 lbs);

e. a redundant bladder system;

f. a slim profile when deflated, with no restriction to head movement while wearing helmet and oxygen mask;

g. minimal heat buildup/retention in a hot cockpit;

h. compatibility with harnesses of parachutes and/or seats of all CF aircraft; and

j. easy to donn/doff.

As a result of complaints from the users, the latest being a UCR from 410 Squadron, Cold Lake (6), DCIEM was tasked to investigate and resolve (7) the reported incompatibility of the -6316 life-preserver and the CF-188 Simplified Combined Harness. MLSD's recommendations to NDHQ/DAS Eng in January 1984 were mainly to modify operating procedures to minimize the problems until a replacement life-preserver could be introduced.

Because of its long history of interest and involvement in life-preserver problems and its mandate as Aviation Life Support specialists, MLSD subsequently started an in-house project to evaluate the life-preservers currently available world-wide against the current international

standards, and the draft SOR (8) A secondary goal was to determine their compatibility with current CF aircrew life support systems. Many test reports of other agencies, e.g. (9,10,11) were useful in identifying the best possible test procedures.

The results of the evaluation are given in this report. Three state-of-the-art life-preservers currently in use with national air forces were studied and compared with the current standard unit:

a. NSN 4220-21-871-6316, Life-Preserver, yoke (CF) (-6316) (Figure 1);

b. SECUMAR Model AUS-2 (Australian Air Force) (AUS) (Figure 2);

c. Saab-Scania Model 601577-5 (Swedish Air Force) (S-S) (Figure 3); and

d. Aerazur Model 35-2, (French Air Force) (Aer) (Figure 4).

METHODS

Subjects

Five subjects, three male and two female, were selected for these tests, in an attempt to cover most of the anthropometric range of aircrew sizes. Relevant anthropometric data of the subjects is recorded in Table 1. Gill (11) found that there is no significant relationship between flotation angle and chest circumference or buttock-heel length of subjects. Because all his subjects were male, however, it was deemed necessary to test the possibility that there is a significant difference between the flotation characteristics of male and female subjects.

Mass of Subjects

Each subject was weighed, dry, wearing each of the clothing ensembles worn in the tests, and then underwater, in bathing suit only. Underwater weight determines each subject's natural buoyancy. For this procedure, depicted in Figure 5, the subject was suspended from the scale by a web belt under the arms. The subject exhaled as much air as possible, submerged, and relaxed while the measurement was taken. Dry weight and lung capacity (Force Vital Capacity,(FCV)) were also measured, and the body density was calculated. The results of all weighings are found in Table 2, Annex B.

Clothing Ensembles

Each subject was fitted with the appropriate clothing ensemble for each test series and retained the articles for the duration of the tests.

Summer Ensemble

All subjects wore the following basic clothing for all of the test measurements done in summer ensemble:

a.	Underwear, light,	NSN 8415-21-870-5475;
b.	Turtleneck, cotton,	NSN 8415-21-870-5480;
c.	Socks, wool	NSN 8440-21-104-2860;
d.	Boots, summer flying	NSN 8430-21-868-7466;
	c/w zipper, boot	NSN 8430-21-840-3764;
e.	Coverall, summer flying	NSN 8415-21-876-5406;
f.	Gloves, flying, shell	NSN 8415-21-744-0140;
g.	Gloves, flying, insert, wool	NSN 8415-21-852-9129;
h.	Helmet, flying DH 41-2,	NSN 8475-21-868-3553; and
j.	Jacket, flying, intermediate	NSN 8415-21-859-0485.

Winter Ensemble

The winter clothing ensemble consists of items b,c,f,g,h above, plus the following:

a.	Underwear, thermal, cotton	NSN 8415-21-859-0727;
b.	Undershirt, thermal, cotton	NSN 8415-21-859-0732;
c.	Jacket, winter flying, Type IV	NSN 8415-21-859-0498;
d.	Pants, winter flying,	NSN 8415-21-859-0472;
e.	Boots, flying, duffle	NSN 8430-21-878-1206;
f.	Socks, duffle	NSN 8440-21-103-7669;
g.	Insoles, felt	NSN 8335-21-857-8949; and
h.	Insoles, mesh	NSN 8335-21-872-4958.

Immersion Suit Ensemble

During the tests using the immersion suit, the following clothing items were worn:

a.	summer items c,d,f,g,h;	
b.	winter items a and b;	
c.	Underwear aircrew (Hodges),	NSN 8415-21-870-4658; and
d.	Coverall, immersion, constant-wear	NSN 8475-21-847-6777.

Life Preservers

Each life-preserver was inflated by its standard CO2 bottle, weighted, and submerged in a tank of cold fresh water. The force (weight) measured by a spring scale was subtracted from the combined dry weight of the life-preserver plus ballast weights to determine the buoyancy. These figures are reasonably representative of the buoyancy that would be provided at 0 deg. C. The internal bladder pressure was measured with a "Magnehelic" pressure gauge, through a quick-disconnect in the oral inflation tube. To ensure the same bladder pressure was used for each subject, this pressure was duplicated, using compressed air, in the water trials using subjects. Only one life-preserver of each type was used in all the trials, and the

waist adjustment and any other straps were adjusted to the same degree of tightness as much as possible, for each subject.

Measurements

Measurements of each subject in each clothing ensemble, and in each life-preserver, were carried out in fresh water in the DCIEM static tank. Water temperature ranged from 11 to 33 deg. C. All measurements were taken four times to assess the reproducibility of the results. The subject entered the pool, swam around for approximately five minutes if the clothing was dry to start, and then all measurements were taken. The subject then left the tank, changed to the second life-preserver, and the procedure was repeated. This sequence continued until all life-preservers had been tested. Each of the subjects went through the same procedure. Finally, the trials were repeated as above, with each subject dressed in the other two clothing ensembles.

a. Flotation Angle was determined by underwater photography of each subject, taken through the glass side in the tank. The subject was centered in the pool near a freely floating weighted pole which served as a vertical reference. The subject relaxed as completely as possible, was instructed to exhale all air, and was photographed. The flotation angle was obtained from the photographs, as follows (eg. Figure 6):

   (1) The plane of flotation was taken as the plane of the trunk, represented by a line passing through the centres of the hip and shoulder joints. The centre of the shoulder joint was found by overlying the photograph with a "bull's eye" and matching it with the curve of the shoulder. The centre of the hip joint was taken as the midpoint of the greatest front-to-back width of the body at buttock level. The line joining these two points was taken as the plane of the trunk. Flotation angle was the angle between the plane of the trunk and the vertical.

b. The self-righting times were determined by measuring in seconds the time taken by the subject to be returned to the face-up position in the water, starting from a face-down attitude flat on the water surface with feet held at the surface by a helper, as shown in Figure 7. The subject held his face out of the water until the surface was still, then took several deep breaths, let out half, and relaxed completely until his motion stopped. The helper released the feet, and the watch was started. The watch was stopped when the helper considered the subject to have achieved a "normal" steady-state flotation attitude, or at 30 seconds if the subject were still floating face down. Two self-righting times were recorded: one with a starting position of arms extended at right angles to the body, the other with arms relaxed by the sides.

c. Subject's mouth-above-water level was measured from the water surface to the lower corner of the mouth of the subject, lying

relaxed in still water. A bar, to which was attached a retractable tape measure, was suspended over the subject's head. With the subject and helper in the tank, the distances from the bar to the water, and to the subject's mouth were recorded. The difference is the level of the subject's mouth above water.

d. Because none of the life-preservers tested met all the ASCC standards, specific tests for compatibility with aircraft systems were not carried out. However, some observations on each item are recorded in the Discussion Section.

RESULTS

Life-Preserver Buoyancy

As can be seen from the results of the buoyancy tests, shown in Table 3., the CF -6316 was the only unit which could not meet the ASCC standard of 16 Kg buoyancy in 0 deg. C water.

Flotation Angle

As can be seen from the results in Table 4. (Annex C), only the -6316 provided near (37 deg.) the specified requirement of 45 ± 10 degrees flotation angle, and then only in flying suits. When in immersion suits the subjects floated parallel to the surface.

Self-Righting Capabilities

The self-righting capability results are shown in Table 5. (Annex B) and Table 6. (Annex E). Only the Aerazur and Secumar AUS-2 met the ASCC five-second standard with all subjects wearing flying suits; none of the life-preservers righted all subjects in immersion suits.

Mouth Above Water Level

The level-above-water measurements are shown in Table 7. (Annex F). From the mean height recorded, it can be seen that the Saab-Scania floated subjects slightly higher than did the others, except when the immersion suit was worn, when the Aerazur was the best performer.

Statistical Analysis

The independent t-test, based on a very limited population sample, indicated that there were no statistically significant ($p < 0.01$) male/female differences in the data. In a few cases, sex differences approached a marginal significance ($p < 0.05$), but these were too infrequent to warrant treating the data as two groups. Subsequent analyses were, therefore, performed by treating all five subjects as a single group.

Paired t-test analyses indicated no statistically significant differences between summer and winter clothing ensembles for any of the tests; however, since the rank order of the life-preservers was different between summer and winter ensembles in the Analysis of Variance (AOV) tests, these data were kept separate.

Performance Comparisons

Comparisons between life-preservers were done with a (one-way) AOV test. The four life-preservers were "treatments" and the variables were mouth-level above water, self-righting time and flotation angle, for each clothing ensemble. From the AOV, the parameters which showed statistical significance (i.e.: $p < .01$) were given Duncan's Test. From the resulting sample rankings, a comparison table was drawn up, shown in Table 8 (Annex B). As indicated in the table, even in cases where the results indicated a difference, no unit was best for all tests. Grouping those that were not statistically ($p < .05$) different, as shown by the underscoring, helps to clarify the results. For instance, the mean self-righting time, in winter clothing, by the Aerazur and the Saab-Scania was virtually the same. Overall, it could be said that the Saab-Scania or Aerazur would perform best at self-righting and at height above water, and that the -6316 is the best at providing a good flotation angle. At this point a relative weighting of the importance of each parameter for any intended role would help in making a recommendation of one unit over another.

DISCUSSION

Life-Preserver Idiosyncrasies

CF -6316. This unit has the lowest (uninflated) profile of all the items tested, and causes no interference with head movements. A well-known drawback of this type of bladder is that it covers most of the front of the abdomen, which makes it uncomfortable in a hot environment. Because of the low pressure in the inflated bladder, the subject's head is not well supported by the collar when in the water. For most subjects, when they were floating face-up, the back of their head and their ears were submerged, as shown in Figure 8. This permits a great heat loss in cold water. The position of the waist-belt is nearly ideal for most subjects, placing the centre of buoyancy coincident with the subject's centre of gravity. It was too low however, on both (75th percentile) female subjects, and also, the belt could not be adjusted enough by the ordinary buckle for them. The only problem encountered with the length (63 cm.) of bladder/stole is that the T-handle harness release of the CF-188 tends to slide under it when the subject is hanging in the harness. The glued-together rubberized nylon bladder has to be proof-tested every two months.

SECUMAR AUS-2. The short (35 cm) bladder stole has a very low profile, and the part behind the neck can be adjusted to move it farther from the nape of the neck. Instead of a vest, the bladder and pockets are attached to a strap suspension. The strap system would allow dissipation of body heat, thus preventing heat loading. However, it is somewhat complicated and requires precise adjustment for each subject. Further, it does not provide a good low attachment of the bladder to the subject's centre of gravity to give a good flotation angle. The female subjects experienced considerable discomfort from the tight straps crossing the breasts. The single Radio-Frequency (RF)-sealed bladder uses a German-made operating head and CO2 bottle which could be interchanged with current CF equipment.

SAAB-SCANIA. The stole of this unit has a very low profile, and is quite short (36 cm), providing little interference with oxygen mask, helmet or

harnesses. The suspension harness is very short, and on all subjects the waist strap came over the rib-cage. The female subjects found this uncomfortable for the same reason as with the SECUMAR. This shortcoming also allowed the whole assembly to slide up when in water, and resulted in the buoyant force being centered higher than the subject's centre of flotation. A poor flotation angle resulted. Adjusting the waist strap entailed pulling both ends of the strap to the rear, a somewhat awkward and difficult manoeuvre for the subject. The lack of a front opening and the small neck hole made the unit hard to donn and doff, especially when bulky clothing was worn. This unit uses a British Walter Kidde head and CO_2 bottle, which were difficult to obtain from the U.K., and which could not be easily replaced with current CF items. The unit has two similar RF-sealed polyurethane bladders, one on top of the other, both inflated from one source.

AERAZUR. The 46 cm-long stole of this unit has a fairly low profile, especially behind the neck and over the shoulders, providing good clearance. The vest is fairly large and heavy, which could create heat loading. The waist strap is easily adjustable by pulling forward, but was above the waist on all but the shortest subjects, and could not be adjusted small enough to fit a small waist. Inflation times were slow, and the stole zipper did not break open completely on all inflations. The single bladder of glued-together polyurethane is one of the largest tested, and is shaped to provide a good self-righting moment. Unfortunately, the large buoyant force is not centered low enough to provide a good flotation angle. The operating head and CO_2 bottle are French-built and are not easily replaceable with current CF items.

CONCLUSIONS

It is concluded that:

a. because of the consistency of the results, the methods are reliable;

b. based on a very limited population sample, the gender of the subject did not cause a significant difference in the performance of the units;

c. the wearing of summer or winter flying ensembles did not produce significant differences in the results;

d. for self-righting, the Aerazur and the AUS-2 performed significantly better than the other two, but none of the units would self-right all subjects within the five seconds maximum, and none would self-right any subject wearing the immersion suit ensemble; and

e. for flotation angle, the -6316 performed significantly better than the other three units despite its low buoyancy; however, none of the units met the 45 deg. ± 10 deg. criterion for all subjects.

RECOMMENDATIONS

This study reinforces earlier findings which suggested that designing a life-preserver to meet all the requirements is difficult, and design of the new CF life-preserver is expected to require considerable design effort. It is recommended that the information of this report be passed on the the designers to simplify the task to whatever extent possible. The points listed below are offered as guidelines:

a. the bladder material should be of the smallest possible bulk consistent with adequate strength;

b. a glued-together bladder is not acceptable in new designs; (radio frequency sealing is preferred)

c. the bladder should have a large volume located directly above the subject's C of G, be quite slim over the shoulders, and with a head support behind the neck;

d. the inflated bladder must render the face-down subject unstable in the rolling or the pitching plane, thus providing a positive righting moment;

e. the bladder must be firmly anchored at its lowest point to the C of G area of any subject, e.g., with a snug, low waist-strap;

f. the deflated bladder should be folded and encased in a short stole which lies flat all around, and which is attached to the vest/suspension only at the inside edges, the outside edges should be free to allow harness straps to pass under;

g. the stole opening system must be simple and not allow hang-ups during inflation;

h. the uninflated unit must be easy to donn/doff - for this a front closure is recommended; and

j. performance tests should be conducted, which will include 5th and 95th percentile CF male and female subjects.

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ANNEX A to
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Figure 1. Current CF Life-Preserver, Jet Aircrew

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Figure 2. Saab-Scania Life-Preserver

Figure 3. Aerazur Life-Preserver

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Figure 4. Secumar Aus-2 Life-Preserver

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Figure 5. Underwater Weighing

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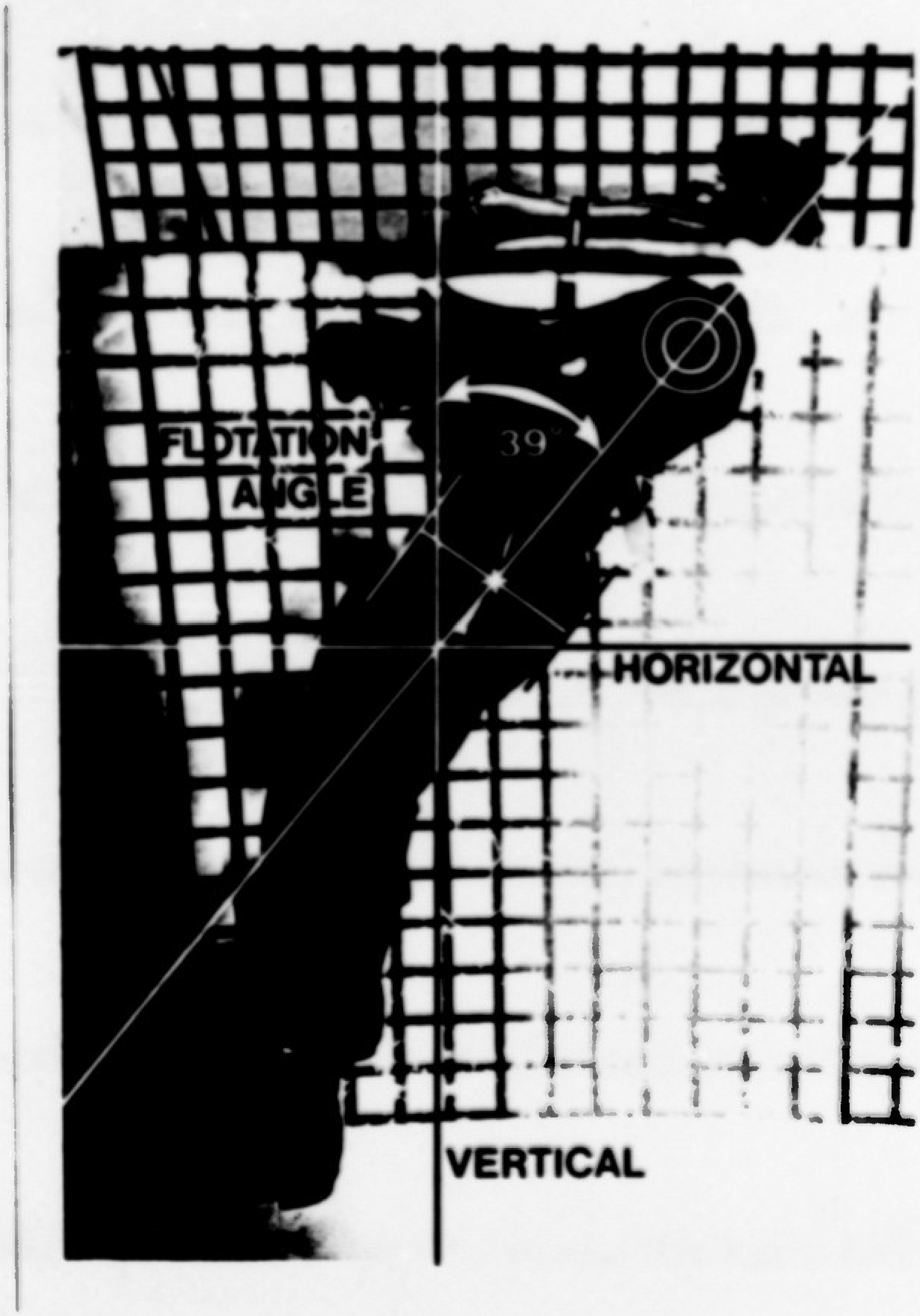

Figure 6. Flotation Angle Measurement

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Figure 7. Self-Righting - Starting Position

Figure 8. Minimal Head-Support of -6316 Life-Preserver

ANNEX B to
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Table 1. Relevant Anthropometric Data

Subject	Stature		Mass		Chest Circumference	
	mm	%ile*	Kg	%ile*	mm	%ile*
GG	2850	90	89.8	85	1066	75
NM	1828	80	79.3	55	1016	50
JS	1727	25	72.4	30	965	25
LP	1676	75	61.5	50	990	90
PR	1650	75	53.3	25	863	25

* Canadian Forces personnel (11, 12)

Table 2. Mass and Underwater Weight of Subjects

Subject	Mass		Weight in Water	Body Density	Mass, dry, dressed in:		
	Kg	%ile	Kg	Kg/L	Summer Kg	Winter Kg	Immersion Kg
GG	89.8	85	3.6	1.059	95.8	98.0	97.1
NM	79.3	60	2.3	1.065	85.6	87.6	87.4
JS	72.4	40	2.2	1.058	79.4	80.1	80.2
LP	61.5	50	2.0	1.052	67.4	69.0	69.0
PR	53.3	25	2.2	1.060	59.1	60.7	61.3

Table 3. Buoyancy of Selected Life-Preservers

Item	Mass Kg	Standard CO2 Charge g	Bladder Pressure mm Hg	Water Temp deg.C	Buoyant Force Kg
a. CF -6316 (Irvin)	1.23	2 x 12	2.2	0.2	15.7
b. Secumar AUS-2	1.33	1 x 30	26	0.2	17.3
c. Saab-Scania	1.42	1 x 33	62	0.2	18.4
d. Aerazur 35-2	1.72	1 x 40	60	0.3	23.2

Table 8. Life-Preserver Comparison, ranked by performance.

Parameter	Poor	------------->		Good
Level - Immersion Above Water	-6316	AUS-2	Aer	S-S
Self-Righting - Winter Arms Extended	-6316	AUS-2	Aer	S-S
Self-Righting - Summer Arms Extended	-6316	AUS-2	S-S	Aer
Self-Righting - Summer Arms at sides	-6316	AUS-2	S-S	Aer
Flotation Angle - Winter	Aer	AUS-2	S-S	-6316
Flotation Angle - Summer	Aer	S-S	AUS-2	-6316

ANNEX C to
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Table 4. Flotation Angle Degrees

SUBJECT	WINTER				SUMMER				IMMERSION			
	-6316	S-S	Aer	AUS	6316	S-S	Aer	AUS	6316	S-S	Aer	AUS
1.	33	27	27	7	42	23	36	11	near horizontal			
	43	30	25	5	39	27	28	15				
	37	28	30	4	39	26	28	13				
	36	28	26	0	35	23	--	15				
mean	37.2	28.2	27.0	5.3	38.8	24.8	30.7	13.5				
2.	30	20	27	8	30	25	33	9				
	31	18	25	10	37	25	30	12				
	22	25	25	8	28	32	28	10				
	26	24	25	--	35	25	36	8				
mean	29.8	21.8	25.5	8.7	32.5	26.8	31.8	9.8				
3.	48	29	37	0	35	33	31	2				
	40	21	39	10	37	27	26	2				
	42	27	31	8	37	26	28	5				
	45	19	38	8	40	36	33	--				
mean	43.8	24.0	35.5	6.0	37.2	30.5	29.5	3.0				
4.	38	31	31	9	50	44	38	24				
	40	31	25	7	52	40	38	19				
	34	31	28	10	50	38	37	22				
	38	36	31	9	48	38	36	22				
mean	37.5	32	28.8	9.2	50.0	40.0	37.2	21.8				
5.	39	34	30	8	45	34	26	15				
	34	34	27	10	44	36	23	21				
	40	34	28	5	45	36	23	16				
	42	32	37	7	44	32	27	19				
mean	39.0	33.5	30.5	7.5	44.5	35.3	24.8	17.8				
mean	37.4	27.9	29.5	7.3	40.6	31.5	30.8	13.2				
S.D.	5.5	5.3	4.2	3.0	6.8	6.4	4.5	6.6				

Table 5. Life-Saver Self-Righting Times (sec.) - Arms At Sides

SUBJECT	WINTER				SUMMER				IMMERSION			
	-6316	S-S	Aer	AUS	6316	S-S	Aer	AUS	6316	S-S	Aer	AUS
1	6.2	-	4.2	5.0	7.0	8.4	4.2	3.0	DNR	DNR	4.0	DNR *
	6.1	9.3	3.8	4.4	7.7	6.5	5.8	3.4	DNR	DNR	4.0	DNR
	6.8	7.9	4.6	5.4	8.0	5.0	5.0	3.0	DNR	DNR	4.0	DNR
	6.2	10.9	3.9	4.8	7.0	5.0	5.9	2.4	DNR	DNR	6.2	DNR
mean	6.3	9.4	4.1	4.9	7.4	6.2	5.2	3.0	-	-	4.6	-
2	4.0	3.6	4.1	4.3	3.5	3.4	3.4	4.0	DNR	DNR	8.5	11.0
	4.6	4.0	3.8	5.3	5.0	4.2	3.0	4.4	DNR	DNR	5.0	DNR
	4.4	4.1	3.9	5.0	4.2	4.0	3.5	4.2	DNR	DNR	12.0	DNR
	4.8	4.0	4.2	4.6	4.9	4.4	3.2	4.2	DNR	DNR	8.0	DNR
mean	4.4	4.0	4.0	4.8	4.4	4.0	3.3	4.2	-	-	8.4	-
3	6.8	5.3	3.8	3.3	5.6	3.9	3.4	3.8	DNR	6.8	4.0	7.0
	7.0	5.7	5.0	3.6	6.0	4.9	3.8	3.1	DNR	11.0	4.2	DNR
	8.0	5.9	3.3	2.8	5.6	4.2	2.8	4.0	DNR	DNR	12.8	DNR
	7.6	5.5	3.9	4.0	5.3	4.8	3.1	3.8	DNR	12.3	11.0	DNR
mean	7.4	5.6	4.0	3.4	5.6	4.4	3.3	3.7	-	10.0	7.0	-
4	4.6	4.9	3.8	4.8	10.0	5.2	3.5	4.0	DNR	DNR	DNR	18.0
	3.8	4.2	4.0	3.5	8.0	4.8	3.5	3.0	DNR	DNR	DNR	DNR
	4.2	3.8	3.0	3.5	8.0	4.2	3.8	3.5	DNR	DNR	DNR	DNR
	4.2	3.8	3.5	4.0	7.5	4.8	3.0	3.0	DNR	DNR	DNR	DNR
mean	4.2	4.2	3.6	4.0	8.4	4.8	3.4	3.4	-	-	-	-
5.	7.0	6.0	4.0	4.0	17.6	5.0	3.2	4.0	DNR	DNR	DNR	DNR
	6.0	5.4	3.8	4.0	17.0	5.7	4.2	4.0	DNR	DNR	DNR	DNR
	5.8	5.8	3.3	4.0	14.5	6.2	4.0	5.0	DNR	DNR	DNR	DNR
	6.0	5.4	3.8	4.4	11.4	5.0	4.5	5.2	DNR	DNR	DNR	DNR
mean	6.2	5.6	3.7	4.1	15.1	5.5	4.0	4.6	-	-	-	-
mean	5.7	5.8	3.9	4.2	8.2	5.0	3.8	3.8	-	-	-	-
S.D.	1.4	2.2	0.7	0.6	4.2	0.9	0.8	0.6				

* DNR - Did Not Right (within 30 sec.)

ANNEX E to
3614H11-19 (MLSD)
28 May 1986

Table 6. Self-Righting Times (sec.) - Arms Extended

SUBJECT	WINTER				SUMMER				IMMERSION			
	6316	S-S	Aer	AUS	6316	S-S	Aer	AUS	6316	S-S	Aer	AUS
1.	7.2	DNR	4.6	5.6	10.0	7.0	6.0	4.0	DNR	DNR	DNR	DNR *
	6.9	7.3	5.0	5.0	9.9	6.0	5.7	3.5	"	"	"	"
	7.2	8.5	5.7	5.0	8.7	6.2	6.0	3.0	"	"	"	"
	6.9	7.9	4.8	5.0	8.4	4.8	5.2	3.0	"	"	"	"
mean	7.0	7.9	5.0	5.2	9.2	6.0	5.7	3.4	-	-	-	-
2.	3.8	5.1	4.5	4.5	4.0	3.6	4.2	4.0	DNR	DNR	DNR	DNR
	4.9	4.3	4.5	5.0	4.8	4.0	3.6	4.2	"	"	"	"
	5.4	4.0	3.6	5.5	4.9	4.0	4.2	3.8	"	"	"	"
	5.1	3.6	4.1	4.8	4.2	4.2	3.8	4.0	"	"	"	"
mean	4.8	4.2	4.2	5.0	4.5	4.0	4.0	4.0				
3.	6.8	5.8	5.3	4.2	5.1	4.9	4.2	4.0	"	"	"	"
	7.1	5.9	4.3	4.1	5.8	4.9	3.9	4.0	"	"	"	"
	6.8	6.0	4.9	4.6	5.4	4.9	4.0	4.2	"	"	"	"
	6.6	6.4	5.1	4.0	5.5	4.7	3.9	4.0	"	"	"	"
mean	6.8	6.0	4.9	4.2	5.4	4.9	4.0	4.0	-	-	-	-
4.	7.0	5.0	4.0	5.0	10.0	6.0	4.0	4.2	DNR	DNR	DNR	36
	7.0	5.2	4.2	5.0	9.0	5.2	4.0	4.0	"	"	"	"
	6.4	5.0	4.0	3.5	10.0	5.8	4.5	4.2	"		"	"
	6.6	5.0	4.0	4.0	8.5	5.5	3.5	3.5	"	"	"	"
mean	6.8	5.0	4.0	4.4	9.4	5.6	4.0	4.0	-	-	-	-
5.	7.6	6.5	4.0	4.0	-	8.2	4.0	4.8	DNR	DNR	DNR	DNR
	7.0	5.6	3.8	4.6	-	8.2	3.8	5.0	"	"	"	"
	6.8	5.5	4.0	4.0	-	7.4	4.7	5.5	"	"	"	"
	6.6	5.8	3.8	4.1	-	8.4	4.9	4.6	"	"	"	"
mean	7.0	5.8	3.9	4.2	-	8.0	4.4	5.0	-	-	-	-
mean	6.5	5.8	4.4	4.6	7.1	5.7	4.4	4.1	-	-	-	-
S.D.	0.9	1.4	0.5	0.5	2.5	1.5	0.7	0.6	-	-	-	-

* DNR - Did Not Right (within 30 sec.)

ANNEX F to
3614H11-19 (MLSD)
28 May 1986

Table 7. Subjects' Mouth Level Above Water (centimeters)

SUBJECT	WINTER				SUMMER				IMMERSION			
	6316	S-S	Aer	AUS	6316	S-S	Aer	AUS	6316	S-S	Aer	AUS
1.	98	86	89	81	116	114	149	57	89	89	108	67
	108	89	108	81	116	143	124	76	86	89	105	57
	102	111	108	81	125	140	140	60	86	95	127	67
	105	111	114	78	121	130	143	60	60	95	130	57
mean	103	99	105	80	120	132	139	63	80	92	118	62
2.	67	67	60	60	68	59	62	41	76	103	130	129
	65	76	73	67	68	67	84	43	73	100	121	118
	65	67	73	67	68	68	86	44	76	79	138	113
	65	67	76	67	71	67	86	65	73	92	132	118
mean	66	69	70	65	69	65	80	48	74	94	130	120
3.	60	95	93	93	79	86	102	70	92	92	133	95
	67	76	86	84	89	92	92	57	95	98	133	92
	75	56	80	87	89	98	89	64	89	98	133	95
	67	59	95	81	89	89	108	60	92	98	127	92
mean	67	72	88	86	86	91	98	63	92	96	132	94
4.	60	89	73	64	79	95	92	76	60	89	137	117
	95	95	73	67	79	114	95	76	60	83	140	133
	67	95	92	73	79	114	95	76	60	83	121	127
	67	95	89	67	79	114	95	76	60	83	114	118
mean	72	94	82	68	79	109	94	76	60	84	128	124
5.	95	60	60	95	89	76	76	60	92	83	105	95
	92	79	64	86	89	95	76	64	89	92	118	92
	95	86	73	95	89	76	75	64	86	92	118	95
	95	98	76	95	89	86	57	70	86	92	114	92
mean	94	81	68	93	89	83	70	64	88	90	114	94
mean	80.4	83	82.6	78.4	88.6	96	96.2	62.8	78.8	91.2	124.4	98.8
S.D.	17	13.2	15.8	11.8	19.2	25.6	26.4	9.9	12.6	4.6	17.9	24.9